the magnetostriction than in the top-type structure.

For example, in the case of a laminated free layer of 3 nm NiFe/0.5 nm CoFe, the NiFe composition of $Ni_{81}Fe_{19}$ (at.%) is not applicable to the top-type structure as the magnetostriction in the positive side is large, but is applicable to the bottom-type structure as the magnetostriction in the positive side is satisfactorily small in practical applications.

The high-conductivity layer is the second significant key point in the invention the same as the top type spin valve as mentioned before. In this Example, the high-conductivity layer is of a Cu film. The most significant role of the high-conductivity film is to make the current center near the free layer as much as possible thereby reduce the current magnetic field.

Still another role of the film is to exhibit the spin filter effect for MR owing to the conductivity of Cu. Therefore, even through the ultra-thin free layer is employed herein, the MR ratio degradation is small.

Regarding the optimum thickness range of the Cu layer, the same as in invention of the top type spin-valve may apply also to the bottom spin-valve of this Example. Like in the top-type structure, the optimum thickness range of the Cu layer varies also in bottom-type structure, depending on the thickness of the free layer, and on the difference in the

thickness between the upper and lower pinned layers of the Synthetic AF. In addition to its role for bias point control and for high MR ratio retention, still another important role of the Cu cap layer is to realize low Hin in ultra-thin free layers. For example, when Hin in a free layer is 30 Oe or more in the absence of the Cu cap layer, it could be reduced to about 10 Oe in the same free layer in the presence of the Cu cap layer.

In variations of (9-1) and (9-2), the high-conductivity layer may be of a laminate film composed of at least two layers, in place of the single-layer high-conductivity layer of Cu as disposed adjacent to the free layer of CoFe. For example, the laminate film for the high-conductivity layer may include Cu/Ru, Cu/Re, Cu/Rh, Cu/Pt, etc. The essential object of the two-layered high-conductivity layer is to control the magnetostriction λs in the free layer. This is because, as so mentioned hereinabove for the top-type structure, the magnetostriction in the free layer of CoFe is influenced by the distortion of the free layer itself. Moreover reduction in Hin is important in the invention. For reducing Hin, the two-layered high-conductivity layer will be effective.

Embodiments of the variations are mentioned below.

5 nanometer Ta/2 nm Ru/10 nm PtMn/2 nm CoFe/0.9 nm Ru/2.5 nm CoFe/2 nm Cu/0.5 nm Co/2 nm NiFe/1.5 nm Cu/1.5 nm Ru/5 nanometer Ta

(9-3)

5 nanometer Ta/1 nm Ru/1 nm NiFeCr/7 nm IrMn/2 nm CoFe/0.9 nm Ru/2.5 nm CoFe/2 nm Cu/0.5 nm Co/2 nm NiFe/1.5 nm Cu/1.5 nm Ru/5 nanometer Ta

(9-4)

In those film structures, the specific resistance of Ru is 30 μΩcm while that of Cu is 10 μΩcm. For the electrical shunt effect, Cu of 1 nanometer Thick will be equivalent to Ru of 3 nanometer Thick. In other words, in the films (9-3) and (9-4), the thickness of the high-conductivity film is equivalent to 2 nanometers in terms of Cu. For the single-layer Cu, its thickness may fall between 0.5 nanometers and 4 nanometers. Therefore, for Ru, its thickness may fall between 0.5 nanometers and 12 nanometers. However, Ru has a higher specific resistance than Cu and its spin filter effect is much lower than that of Cu. Therefore, for the high-conductivity layer to be adjacent to CoFe, Cu is preferred to Ru. Too thick Ru is unfavorable, as not satisfying narrow gaps. For these reasons, therefore, it is desirable that Cu is positioned adjacent to CoFe, while having a thickness of from 0.5 to 2 nanometers or so, and the other additional metal layer is positioned over the Cu layer to give the laminated film for the high-conductivity layer.

Example 4: Bottom SFSV (with free CoFe layer)

5 nanometer Ta/2 nm Ru/10 nm PtMn/2 nm CoFe/0.9 nm Ru/2.5 nm CoFe/2 nm Cu/2 nm CoFe/2 nm Cu/5 nanometer Ta (10-